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ventrally, appears throughout the entire length, to a condition where only the occasional presence of a few degenerating cells indicates the location of the atrophied duct.

Increased activity of a single kidney also has a definite effect on the segmental duct of that side. Cross sections of the duct of an individual with unilateral operation, when compared with either of the ducts of a normal larva of the same stage, show a marked increase in diameter.

The mesonephroi of both sides develop normally, at least in the early stages, even after excision of one pronephros. Non-development of the segmental duct in one instance left the mesonephric tubules disconnected on that side, and with no outlet for excretory products. No specimens have yet been kept a sufficient length of time to determine the ultimate outcome of this abnormal condition.

In brief then, the following conclusions may be drawn.

1. Removal of both pronephroi in *Amblystoma* larvae induces conditions leading to oedema and subsequent death, though the presence of one head kidney is sufficient to keep the embryo in a condition of health.

2. Excision of one head kidney brings about an increase in size in the remaining organ, and also in the diameter of the segmental duct on that side.

3. Removal of one pronephros has no essential effect on the development of the pronephric glomerulus of that side, but the segmental duct appears in varying stages of atrophy.

4. Anterior and posterior nephrostomes may regenerate from the coelomic epithelium.

5. Early developmental stages of the mesonephros are normal, even after excision of one head kidney.

ON THE PRESENCE OF A MEDIAN EYE IN TRILOBITES

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The entirely extinct sub-class Trilobita of the Crustaceans, comprising about 1840 species divided into some 185 genera, has always held a central place in the phylogenetic history of all classes of Crustacea. It is becoming *not only* more probable that the Ostracoda and Cirripedia were developed from the trilobites, but that also the insect subphylum has taken its origin from this ancient class of arthropods. Some authors derive the Xiphosura and Eurypterida and through them the scorpions and all later arachnidians from the trilobites, and others again, as Patten,

trace the vertebrates back to the Xiphosura and Eurypterida. The phylogenetic importance of the trilobites, which were the dominant animal class in the Cambrian era, is therefore assured, and it is for this reason that observations of new structures in the trilobites are of greater interest than they might otherwise be.

An organ not heretofore recognized in the trilobites is the median or parietal eye on the glabella, and yet the question of its presence or absence in the trilobites is of considerable phylogenetic importance. Beecher, through whose observations we have learned so much of the ventral anatomy of the trilobites, would ally them closely with the Phyllopods (Branchiopoda) and Walcott, who has made us acquainted with an unexpected wealth of Cambrian trilobites and other crustaceans, would directly derive them from primitive Branchiopods correlated for convenience with Apus-like forms. On the other hand we find authors such as Kingsley, Bernard and Jaekel, who advance arguments to prove that the trilobites can be traced back directly to arthropods more primitive than any crustaceans, as for example, the annelids. Bernard would even not place them in the class Crustacea.

In these discussions the absence of median or parietal eyes in the trilobites has been emphasized as a feature distinguishing them from most primitive crustaceans, notably the Phyllopoda, as well as from the Merostomes. It is therefore of interest that the presence of such median eyes can be demonstrated in this group.

The median eye appears, in the majority of cases, as a single tubercle upon the glabella. This tubercle has so far been recognized in upward of thirty genera, among them all genera of the Asaphidae and representatives of most other families of the trilobites. In studying the structure of the tubercle it was found that the median eye presents all stages of development seen in other crustaceans, from mere transparent thinner spots of the test to a lenticular body covered by a thin cornea. The lenticular body is frequently recognized by the pit in the interior cast of the tubercle; it was seen in sections of *Cryptolithus* (*Trinucleus*) *tesselatus* from the Trenton limestone of New York. Here it appears as a glossy, pearly body in the interior cast of the eye tubercle when the thin cornea is removed. In sections it is seen to be composed of the same substance as the matrix, but bounded on the under side by a carbonaceous layer; and it is also observed that the test above the lenticular body is thinned to one-half its normal thickness, thus forming a thin cornea. From the absence of a separate crystalline structure in the lens, and the presence of the carbonaceous division line, we infer that there was no hard chitinous lens that would become a separate center

of crystallization in fossilization, as in the lateral eyes of the trilobites, but one corresponding to that of the parietal eye of other crustaceans, and especially of the phyllopods, which is a lens- or pear-shaped sac, usually filled with water. The parietal eye of the trilobites is hence not at all comparable to the larval ocelli of insects or the parietal eye of *Limulus*, the eurypterids and arachnids in general, where the chitinous integument thickens into an exterior lens, but it agrees well in its structure with the median eye of the crustaceans; the thin black layer at the base of the lenticular body being derived from the pigment of the retina. Whether the lenticular cavity was filled with sea-water or a body fluid is not known, but there are indications that some trilobites may have possessed a pore on the apex of the tubercle, giving the sea-water access to the interior.

Indirect evidence for the visual function of the tubercle is seen in the following facts:

The eye tubercle is the sole prominence on the otherwise smooth glabella in the *Asaphidae*, *Trinucleidae*, etc. It must therefore have a function requiring prominence for its performance. It is always situated at the highest spot of the carapace, either on the apex of the bulging frontal lobe of the glabella as in *Cryptolithus* (*Trinucleus*), or where the glabella abruptly bends downward on the prominent posterior portion between the last glabellar lobes (*Isotelus* and *Asaphus*). It is, further, generally situated between the posterior portions of the lateral or compound eyes. This position is explained by the fact that the median or parietal eye according to its origin is always nearest to the brain and this is, in the phyllopods and most other crustaceans, situated in the dorsal region of the head, beneath or between the lateral eyes. As in the eurypterids, so also in the trilobites, the median eye is often found at the posterior extremity of a distinct crest, extending backward a short distance upon the glabella. This crest is probably an analogue of the 'eye-line' of the lateral eyes of the primitive trilobites, and at least in part, marks the path of the nerve leading to the median eye. As in the crustaceans and eurypterids, the median eye tubercle is relatively largest and most prominent in the earliest growth stages, and in the later stages it may entirely disappear, as in *Isotelus gigas*. It is likewise better developed in the more primitive orders of the trilobites; and the phylogenetically late families of the highest order, the Proparia, viz., the *Calymenidae* and *Phacopidae*, seem to have practically lost the median eye. The Ordovician and Silurian trilobites show well developed median eye tubercles; the Devonian forms lack them; the median eye, as in the higher crustaceans, having been either reduced again to

a transparent spot in the test and wandered inward or become altogether effaced. In the Cambrian trilobites, the tubercle, for the most part, is also absent; the median eye from the present evidence, being still in its most primitive form of one or two transparent spots of the test.

It is a distinct fact pointing to a visual function of the median tubercle that the genera usually considered as blind because of reduced or absent lateral eyes, are apt to show these median eye tubercles most distinctly, as notably *Cryptolithus*, *Trinucleus*, *Dionide*, *Dindymene*, and also *Agnostus*, *Microdiscus* and *Ampyx*, while on the other hand the genera, *Phacops* and *Dalmanites* with their highly developed lateral eyes, show the least trace of the median eye. Its constant presence in a great number of genera is further evidence of its important function; and finally the fact that all lower crustaceans typically possess the median or parietal eye and that for that reason zoologists of standing have already simply assumed the presence of this organ in the trilobites, makes it a reasonable inference that these primitive early crustaceans should have also possessed the median eye, in at least some stages of their evolution, and that is what the writer hopes to have demonstrated.

A fuller account of this investigation is being printed in a New York State Museum Bulletin.

THE NATURE OF MECHANICAL STIMULATION

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The effects of certain kinds of stimuli can be referred directly to chemical changes which they produce in the protoplasm, but there are other kinds which appear to operate by physical means only. In the latter category are such stimuli as contact, mechanical shock and gravitation. While their action appears at first sight to be purely mechanical, they are able to produce effects so much like those of chemical stimuli that it appears probable that in every case their action must involve chemical changes.

The chief difficulty which confronts a theory of mechanical stimulation appears to be this, How can purely physical alterations in the protoplasm give rise to chemical changes? It would seem that a satisfactory solution of this problem might serve to bring all kinds of stimulation under a common point of view, by showing that a stimulus acts in every case by the production of chemical reactions.